PB-228 370

DETERMINATION OF APPARENT SIGNIFICANT DIFFERENCES IN CAPITAL COSTS OF CONSTRUCTING SEWAGE TREATMENT PLANTS IN NEW ENGLAND VS. COMPARABLE PLANTS IN OTHER REGIONS IN THE UNITED STATES

Roy F. Weston, Incorporated
West Chester, Pennsylvania

15 June 1970

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CAPITAL COST COMPARISON SEWAGE TREATMENT PLANTS NEW ENGLAND vs. OTHER REGIONS

Environmental Protection Agency
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Determination of Apparent Significant Differences in Capital Costs of Constructing Sewage Treatment Plants in New England vs. Comparable Plants in Other Regions in the United States

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74

TABLE OF CONTENTS

	Page
LIST OF TABLES	
INTRODUCTION	1
Scope and Objectives	1
Selection of Plants for Evaluation	2
Types of Information used as Basis for Comparison	3
Data Collection and Analytical Procedures	4
DESCRIPTIONS AND COST SUMMARIES OF INDIVIDUAL TREATMENT PLANTS	6
Plant No. 1 - City of San Clemente, California	7
Summary of Design Basis and Major Equipment Sizes	8
Plant No. 2 - Santee County Water District, Santee, California	13
Summary of Design Basis and Major Equipment Sizes	14
Plant No. 3 - Hemet-San Jacinto Valley	18
Summary of Design Basis and Major Equipment Sizes	19
Plant No. 4 - City of Denton, Texas	23
Summary of Design Basis and Major Equipment Sizes	24
Plant No. 5 - City of Titusville, Florida	31
Summary of Design Basis and Major Equipment Sizes	32
Plant No. 6 - City of Batavia, New York	36
Summary of Design Basis and Major Equipment Sizes	37
Plant No. 7 - Town of Lee, Massachusetts	41
Summary of Design Basis and Major Equipment Sizes	42
Plant No. 8 - Beaver Brook District, City of Milford, Connecticut	46
Summary of Design Basis and Major Equipment Sizes	47
Plant No. 9 - Town of East Windsor, Connecticut	52
Summary of Design Basis and Major Equipment Sizes	53
SUMMARY OF TREATMENT PLANT COSTS	57
RATIONALE FOR DEDUCTION A	63
CONCLUSIONS	66
APPENDIX A	
Fig. A-1 - Comparison of Number of Plants Vs. Cost Per mgd	
Fig. A-2 - Comparison of Total Cost Vs. Plant Capacity	

LIST OF TABLES

Table No.	Title	Page
1	Construction Cost Breakdown Based on FWQA Cost Escalation Factor Plant No. 1	11
2	Construction Cost Breakdown Based on ENR Cost Escalation Factor Plant No. 1	12
3	Construction Cost Breakdown Based on FWQA Cost Escalation Factor Plant No. 2	16
4	Construction Cost Breakdown Based on ENR Cost Escalation Factor Plant No. 2	17
5	Construction Cost Breakdown Based on FWQA Cost Escalation Factor Plant No. 3	21
6	Construction Cost Breakdown Based on ENR Cost Escalation Factor Plant No. 3	22
7	Construction Cost Breakdown Based on FWQA Cost Escalation Factor Plant No. 4 (Expansion)	27
8	Construction Cost Breakdown Based on FWQA Escalation Factor Plant No. 4 (Existing)	28
9	Construction Cost Breakdown Based on ENR Cost Escalation Index Plant No. 4 (Expansion)	29
10	Construction Cost Breakdown Based on ENR Expansion Factor Plant No. 4 (Existing)	30

LIST OF TABLES
(continued)

Table No.	Title	Page
11	Construction Cost Breakdown Based on FWQA Cost Escalation Factor Plant No. 5	34
12	Construction Cost Breakdown Based on ENR Cost Escalation Factor Plant No. 5	35
13	Construction Cost Breakdown Based on FWQA Cost Escalation Factor Plant No. 6	39
14	Construction Cost Breakdown Based on ENR Escalation Factor Plant No. 6	40
15	Construction Cost Breakdown Based on FWQA Cost Escalation Factor Plant No. 7	44
16	Construction Cost Breakdown Based on ENR Cost Escalation Factor Plant No. 7	45
17	Construction Cost Breakdown Based on FWQA Cost Escalation Factor Plant No. 8	50
18	Construction Cost Breakdown Based on ENR Cost Escalation Factor Plant No. 8	51
19	Construction Cost Breakdown Based on FWQA Cost Escalation Factor Plant No. 9	55
20	Construction Cost Breakdown Based on ENR Cost Escalation Factor Plant No. 9	56
21	Summary of Treatment Plant Costs Per mgd	58
22	Summary of Treatment Plant Cost Per mgd Arranged in Series of Increasing Cost	59
23	Data Matrix of Treatment Plant Costs Dollars Per mgd	60
24	Cost Comparisons Based on Hydraulic Capacity	61

Determination of Apparent Significant Differences in Capital Costs of Constructing Sewage Treatment Plants in New England vs. Comparable Plants in Other Regions of the United States

INTRODUCTION

Scope and Objectives

The general purpose of this study is to determine whether there were significant differences in the capital costs for construction of sewage treatment plants in different sections of the United States. Determination of construction cost differences for the Northeast Region was of particular interest in this investigation.

The project scope consisted of the following:

1. Field inspection of treatment plants of comparable size, degree of treatment and design standards in various regions of the United States as mutually selected by ROY F. WESTON and the Federal Water Quality Administration. The plants selected for study are located in the following States: Connecticut, New York, Florida, Texas, California and Massachusetts.

2. Conferences with the design engineers to obtain basic design concepts relative to the treatment plants to gather information pertaining to the engineers' surveillance of the construction projects.

3. Conferences with the contractors who constructed the plants to obtain cost breakdown information and construction problems, if any, that may have affected the cost of construction.

4. Preparation of data summary sheets for each treatment plant, including the plant location, plant capacity, design engineer and date of bid. The data summary sheets also included a description of each cost element, cost adjustments as a function of time and location, cost per mgd, and the percent of total construction cost. In addition, miscellaneous items were added to the data sheets such as emergency power, blower air capacity per mgd, and total plant horsepower.

   Two cost evaluations were made for each plant. One cost standard was based on the Engineering News Record with a base date of 1 December 1969; the second was based on the Municipal Waste Treatment Plant Cost Index, published by the U. S. Department of Interior, FWQA, Division of Federal grants, with a base date of 1 August 1969.

5. Preparation of a data matrix summarizing the pertinent cost elements for each of the nine sewage treatment plants, including cost deductions, as follows:

   Deduction A - Location, land conditions and contractor location.

   Deduction B - Sewage lift stations.

6. Summarize the preliminary findings pertinent to the reasons for the apparent cost differences between sewage treatment plants within the United States.

The overall objective is to provide a basis for determining the cost differentials on an individual plant basis, as well as determining the comparison of cost differentials between treatment plants. The evaluation of cost differentials between treatment plants is viewed in terms of cost elements and the total construction cost.

Selection of Plants for Evaluation

The cost survey is based on the following sewage treatment plants:

1. San Clemente, California
2. Santee, California

3. Hemet, California
4. Denton, Texas
5. Titusville, Florida
6. Batavia, New York
7. Lee, Massachusetts
8. Milford, Connecticut
9. East Windsor, Connecticut

As defined by EPA/OWP, the Northeast Region consists of the six New England States, New York, New Jersey and Delaware. Four treatment plants were selected from this region: Batavia, New York; Lee, Massachusetts; East Windsor, Connecticut; and Milford, Connecticut.

The remaining plants selected for the study were located at Titusville, Florida; Denton, Texas; and Hemet, San Clemente, and Santee, California. These five plants provided the control group to which the four Northeast plants were compared. Other combinations of the nine plants provided additional insights into the interrelationships of the cost elements.

Types of Information used as Basis for Comparison

The pertinent information collected during the project included design standards, type of process, wastewater characteristics, treatment efficiencies, plant performance, type of construction, proximity to urban area, labor pools, material suppliers, dates and duration of construction, and weather conditions during construction. More specifically, it included:

1. Plans and specifications.
2. Engineer's design report.
3. Engineer's cost estimate.
4. Bid tabulations.
5. Federal grant involved.
6. Plant and area considerations.
7. Process design.
8. Unit Processes.

9. Material considerations.

10. Instrumentation.

11. Interim reports, such as progress reports and payments.

12. Operation and maintenance reports.

13. Miscellaneous information generated by our interviews.

Data Collection and Analytical Procedures

In order to provide for the logical development and analysis of the data obtained during this study, the project was divided into three distinct phases, namely:

Phase I - Data Collection
Phase II - Data Organization
Phase III - Data Analysis

At the outset of Phase I, treatment plants were mutually selected by ROY F. WESTON and OWP. These plants were to have a design flow of between 0.8 and 5.0 million gallons per day (mgd), to be less than five years old, and to be providing some form of activated sludge treatment. After selecting the nine treatment plants referred to in this study, each plant was visited and the individual Design Consultant and the Contractor associated with plant construction was also interviewed. The principal purposes of these visits and meetings involved gathering meaningful information on concepts, design parameters, and other pertinent factors that could have affected the final cost of the treatment plant.

In Phase II, the data were organized into a data matrix. This was done by first subdividing the total construction cost of each plant into the appropriate bid categories and then escalating the cost of each category at the time of the bid to more recent costs. Costs were escalated to 1 August 1969 based on the FWQA construction cost index and to 1 December 1969 based on the Engineering News Record Cost Index. Subsequently, these cost figures were adjusted for a common location at Washington, D.C. After adjusting for both escalating costs and location,

the construction costs were derived in terms of dollars per million gallons per day (mgd) of design flow capacity. The final step of this Phase involved the summarization of all nine treatment plant costs within the data matrix in order to facilitate data interpretation.

Phase III consisted of an analysis of the cost information to determine the reasons for the apparent cost differences.

DESCRIPTIONS AND COST SUMMARIES OF INDIVIDUAL TREATMENT PLANTS

General

This section describes each treatment plant as to its general location, the design capacities and treatment efficiences, and includes a brief summary of those items which could possibly affect the ultimate construction cost, such as type of labor used and weather conditions during construction. The description of each plant is followed by a summary of the original design basis and the major requipment sizes for that particular facility. In addition, a cost data sheet, presenting original costs, escalated and adjusted costs for time and location, and a dollar value per mgd treated for each phase of plant construction, has been included for each of the facilities.

Plant No. 1 - City of San Clemente, California

The City of San Clemente is constructing a new activated sludge waste treatment plant. The facility was engineered by Engineering Sciences and is being constructed by Weardco Construction Corporation of Santa Fe Springs, California.

The 1967 population for the City was reported at 16,100. The treatment plant was designed for the year 1980, when the population is expected to reach 60,000. The average design flow is 4.0 mgd, with a peak flow factor of two times this amount. On this design basis, the average flow per capita per day is approximately 67 gallons.

The City of San Clemente facility will include an influent pumping station, grit chamber, primary treatment tanks, aeration tanks, final clarification tanks, a chlorine contact tank, a sludge thickener, and an incinerator. The design loading is 360 mg/L BOD_5 and 340 mg/L suspended solids, with removal efficiencies of 93 to 97 percent of BOD and 99 percent of the suspended solids. The aeration tanks are designed to allow operation either as step aeration, contact reaeration, or plug flow system. The control building for the facility appears to be plain and inexpensive in design, but adequate.

The construction period for this area is essentially twelve months of the year; weather conditions during construction have been favorable and have caused no delays. It is also important to note that the labor force for this project consists primarily of local union labor. Construction surveillance is being provided by the City of San Clemente. Only two contractors submitted bids for the project, with a difference of $217,400 in the base bids.

Plant No. 1 - San Clemente, California
SUMMARY OF DESIGN BASIS AND MAJOR EQUIPMENT SIZES

General Basis of Design

Design Period	1980
Design Population	60,000
Average Design Flow	4 mgd
Peak Factor	2.0
Average BOD_5	360 mg/L
Average Suspended Solids	340 mg/L
Raw Sewage	
BOD	12,000 lb./day
SS	11,350 lbs./day
Settled Sludge	
BOD	7,800 lbs./day
SS	4,540 lbs./day
Secondary Effluent	
BOD	720 lbs./day
SS	560 lbs./day
Filtered Effluent	
BOD	670 lbs./day or 20 mg/L
SS	Nil
Total Plant Removal	
BOD	93 to 97 percent
SS	99 + percent

Treatment Facilities

Influent Pump Station	
Number of Pumps	Three
Capacity, each	2,800 gpm
Inlet Structure	
Comminutor	24"
Bar rack	36"
Grit Chamber	
Number	One
Type	Aerated
Air Required	120-300 cfm
Dimensions	
Length	18 ft.
Width	16 ft.
Depth	10.5 ft. SWD
Primary Tanks	
Flow	4 mgd
Number of Tanks	3
Total Volume	40,500 cu. ft.
Detention Time	1.82 hours
Design Surface Overflow Rate	990 gal/sq. ft./day

Dimensions	
Length	90 ft.
Width	15 ft.
Depth	10 ft. SWD
Sludge Pumps	
Number	Two
Capacity of each	200 gpm
Aeration Tanks	
Influent Flow	4 mgd
Recycle Rate	25 - 70 percent
Loading	0.4 lbs. BOD/day/lb. MLVSS in aeration
Detention Time	6.8 hours
Total Volume	377,500 cu. ft.
Number of Tanks	Four
Dimensions	
Length	135 ft.
Width	25 ft.
Depth	25 ft. SWD
Air Required	2,000 cu. ft./lb. BOD removed.
Final Tanks	
Flow	4 mgd
Number of Tanks	Three
Total Volume	64,500 cu. ft.
Detention Time	2.96 hours
Design Surface Overflow Rate	606 gal/sq. ft./day
Dimensions	
Length	110 ft.
Width	20 ft.
Depth	905 ft.
Waste Sludge Pumps	
Number of Pumps	Two
Capacity	300 gpm
Sludge Recycle Pumps	
Number of Pumps	Two
Capacity	2,000 gpm
Chlorine Contact Tanks	
Number of Tanks	Two
Number of Compartments/tanks	Six
Detention Time	30 minutes
Dimension each compartment	
Length	20 ft.
Width	5 ft.
Depth	9 ft. SWD

Filters	
Number of Tanks	One (dual compartment)
Size	2.2 ft. Diameter x 15 ft.
Filtration Rate	4 gpm/sq. ft.
Backwash Rate	10 - 15 gpm/sq. ft.
Blower	Positive Displacement
Capacity	1,150 cfm
Backwash Return Pumps	Two at 2,800 gpm each
Sludge Thickener	
Design Loading	8 lbs. dry solids/sq. ft./day
Dimensions	
Diameter	45 ft.
Depth	10 ft. SWD
Incinerator	
Type	Multiple Hearth
Feed	11,000 lbs. dry solids/day
Cake Solids	23 percent

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Table 1

Construction Cost Breakdown
Based on FWQA Cost Escalation Factor
Plant No. 1

PLANT: Water Reclamation Plant
LOCATION: San Clemente, California
PLANT CAPACITY: 4.0 MGD

ENGINEER: Engineering Science
LOCATION: Arcadia, California
DATE OF BID 6-23-69

DESCRIPTION	COST	ESCALATE COST TO AUGUST 1, 1969 (FWQA) 1.0	ADJUST COST TO LOCATION (WASH. D.C.= 1.0) .83	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	28,000	28,000	26,040	6,508	1.2
SITE WORK-DEWATER	1,500	1,500	1,395	349	8.1
CLEAR & GRUB	38,000	38,000	35,340	8,835	1.8
LANDSCAPING	25,500	25,500	23,715	5,929	1.1
EXCAVATE & BACK.	58,000	58,000	53,940	13,485	2.6
CONCRETE ITEMS	438,300	438,300	407,619	101,905	19.3
STRUCTURAL STEEL	60,000	60,000	55,800	13,950	2.6
CONTROL BUILDING	75,000	75,000	69,750	17,438	3.3
YARD PIPING	247,500	247,500	230,175	57,544	10.9
MECHANICAL PIP'G	7,200	7,200	6,696	1,674	0.3
MECHANICAL EQUIP.	391,730	391,730	364,309	91,077	17.3
ELECTRICAL	216,000	216,000	200,880	50,220	9.5
INSTRUMENTATION	134,000	134,000	124,620	31,155	5.9
SLUDGE HANDLING	521,000	521,000	484,530	121,133	23.0
MISCELLANEOUS	23,910	23,910	22,236	5,559	1.1
TOTAL	2,265,640	2,265,640	2,107,045	526,761	100.0
MISC. ITEMS					
EMERGENCY POWER	150 KW Generator				
CFM/MGD	3750				
HORSEPOWER	1225				

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Table 2

Construction Cost Breakdown
Based on ENR Cost Escalation Factor
Plant No. 1

PLANT: Water Reclamation Plant
LOCATION: San Clemente, California
PLANT CAPACITY: 4.0 MGD

ENGINEER: Engineering - Science
LOCATION: Arcadia, California
DATE OF BID 6-23-69

DESCRIPTION	COST	ESCALATE COST TO DECEMBER 1, 1969 (ENR) 1.006	ADJUST COST TO LOCATION (WASH, D.C.= 1.0) .83	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	28,000	28,017	23,254	5,813	1.2
SITE WORK-DEWATER	1,500	1,500	1,245	311	0.1
CLEAR & GRUB	38,000	38,023	31,559	7,890	1.8
LANDSCAPING	25,500	25,515	21,177	5,294	1.1
EXCAVATE & BACK.	58,000	58,035	48,169	12,042	2.6
CONCRETE ITEMS	438,300	438,563	364,007	91,002	19.3
STRUCTURAL STEEL	60,000	60,036	49,830	12,458	2.6
CONTROL BUILDING	75,000	75,045	62,287	15,572	3.3
YARD PIPING	247,500	247,649	205,549	51,387	10.9
MECHANICAL PIP'G	7,200	7,204	5,979	1,495	0.3
MECHANICAL EQUIP.	391,730	391,965	325,332	81,333	17.3
ELECTRICAL	216,000	216,130	179,388	44,847	9.5
INSTRUMENTATION	134,000	134,080	111,286	27,822	5.9
SLUDGE HANDLING	521,000	521,313	432,690	108,172	23.0
MISCELLANEOUS	23,910	23,924	19,857	4,964	1.1
TOTAL	2,265,640	2,266,999	1,881,609	470,402	100.0

MISC. ITEMS	
EMERGENCY POWER	150 KW Generator
CFM/MGD	3750
HORSEPOWER	1225

Plant No. 2 - Santee County Water District, Santee, California

The County of Santee presently operates a 4.0 mgd activated sludge plant which can be operated as either a conventional or step aeration facility. This plant is located on the outskirts of a residential district in a small valley, with hills on two sides of the site. Engineering Science designed the facility, and the construction services were provided by the Weardco Construction Company.

At the time the plant was designed in 1966, the population was approximately 14,000. The design flow was 4.0 mgd at a design population of 48,000. On this basis, the average flow per capita per day is 83 gallons.

The treatment plant includes primary clarification, aeration, secondary clarification, and a wet air oxidation sludge disposal unit. The design loading was 8,300 lbs/day of BOD, and the design effluent BOD concentration was 20 mg/L.

Construction of the facility took place between October 1966 and December 1967. Local unionized labor participated in construction. The contractor did not encounter any unforseen problems, and weather conditions were favorable throughout construction. Construction surveillance was provided by the Santee County Water District. The aesthetic appearance of the facility was attractive, and it was accentuated by the control building, which included an elaborate meeting room.

Seven contractors submitted bids for construction of the Water Reclamation Plant; however, one contractor withdrew his bid. The remaining bids varied from $38,884 to $138,975 above Weardco Construction Company's bid.

Plant No. 2 Santee, California

SUMMARY OF DESIGN BASINS AND MAJOR EQUIPMENT SIZES

General Basis of Design

Design Population	48,000
Design Flow	4 mgd
Design BOD Loading	8300 lbs/day
Final Effluent BOD	20 mg/L
Expected Plant Efficiencies	
BOD	90-95 percent
Suspended Solids	90-95 percent

Treatment Facilities

Primary Settling Tanks	
Influent Flow	4 mgd
Number of Tanks	Two
Detention Time	1.9 hours
Design Overflow Rate	950 gals/sq.ft./day
Assumed Removals	
Suspended Solids	65 percent
BOD	35 percent
Dimensions	
Length	140 ft.
Width	15 ft.
Depth	10 ft. SWD
Manufacturer	Walker
Aeration Tanks	
Total Volume	142,000 cu.ft.
Loading	38 lbs BOD/1000 cu.ft.
Operation	Step-aeration or conventional
Blowers	
Number	Three
Type	Centrifugal
Capacity	3500 cfm
Air Required	1500 cu.ft/lb BOD

Final Tanks	
Number of Tanks	Two
Design Overflow Rate	910 gals/sq.ft./day
Detention Time	2 hours
Dimensions	
Length	110 ft.
Width	20 ft.
Depth	10 ft. SWD
Manufacturer	Walker
Sludge Disposal	
Method	Wet Air Oxidation
Solids Concentration	3.5 percent
Manufacturer	Zimpro

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Table 3

Construction Cost Breakdown
Based on FWQA Cost Escalation Factor
Plant No. 2

PLANT: Water Reclamation Plant
LOCATION: Santee, California
PLANT CAPACITY: 4.0 MGD

ENGINEER: Engineering Science
LOCATION: Arcadia, California
DATE OF BID: 10-3-66

DESCRIPTION	COST	ESCALATE COST TO AUGUST 1 1969 (FWQA) 1.14	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) .93	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	16,000	18,240	16,963	4,241	1.1
SITE WORK-DEWATER	17,000	19,380	18,023	4,506	1.2
CLEAR & GRUB	10,600	12,084	11,238	2,810	0.7
LANDSCAPING	41,300	47,082	43,786	10,947	2.8
EXCAVATE & BACK.	42,400	48,336	44,952	11,238	2.9
CONCRETE ITEMS	316,680	361,015	335,744	83,936	21.6
STRUCTURAL STEEL	35,500	40,470	37,637	9,409	2.5
CONTROL BUILDING	136,200	155,268	144,399	36,100	9.3
YARD PIPING	138,070	157,400	146,382	36,596	9.4
MECHANICAL PIP'G	57,200	65,208	60,643	15,161	3.9
MECHANICAL EQUIP.	247,402	282,038	262,295	65,574	16.9
ELECTRICAL	53,500	60,990	56,721	14,180	3.7
INSTRUMENTATION	69,500	79,230	73,684	18,421	4.7
SLUDGE HANDLING	248,930	283,780	263,915	65,979	17.0
MISC.	33,753.	38,479	35,785	8,946	2.3
TOTAL	1,464,035.	1,669,180	1,552,167	388,044	100

MISC. ITEMS	
EMERGENCY POWER	
CFM/MGD	
HORSEPOWER	707

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Table 4

Construction Cost Breakdown
Based on ENR Cost Escalation Facotr
Plant No. 2

PLANT: Water Reclamation Plant
LOCATION: Santee, California
PLANT CAPACITY: 4.0 MGD

ENGINEER: Engineering Science
LOCATION: Arcadia, California
DATE OF BID: 3 OCT 1966

DESCRIPTION	COST	ESCALATE COST TO DECEMBER 1, 1969 (ENR) 1.22	ADJUST COST TO LOCATION (WASH. D.C.= 1.0) .83	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	16,000	19,520	16,202	4,050	1.1
SITE WORK-DEWATER	17,000	20,740	17,214	4,303	1.2
CLEAR & GRUB	10,600	12,932	10,734	2,684	0.7
PAVING AND LANDSCAPING	41,300	50,386	41,820	10,455	2.8
EXCAVATE & BACK.	42,400	51,728	42,935	10,734	2.9
CONCRETE ITEMS	316,680	386,350	320,670	80,168	21.6
STRUCTURAL STEEL	35,500	43,310	35,947	8,987	2.5
CONTROL BUILDING	136,200	166,164	137,916	34,479	9.3
YARD PIPING	138,070	168,445	139,809	34,952	9.4
MECHANICAL PIP'G	57,200	69,784	57,921	14,480	3.9
MECHANICAL EQUIP.	247,402	301,830	250,519	62,630	16.9
ELECTRICAL	53,500	65,270	54,174	13,543	3.7
INSTRUMENTATION	69,500	84,790	70,376	17,594	4.7
SLUDGE HANDLING	248,930	303,695	252,067	63,017	17.0
MISC.	33,753.	41,179	34,178	8,544	2.3
TOTAL	1,464,035	1,786,123	1,482,482	370,620	100
MISC. ITEMS					
EMERGENCY POWER					
CFM/MGD					
HORSEPOWER	707				

Plant No. 3 - Hemet-San Jacinto Valley

The Eastern Municipal Water District of California operates a 2.5 mgd waste treatment plant located in Hemet, California. The San Jacinto Valley is primarily a rural area consisting of many farms and modern residential areas developed mainly for those in retirement. The treatment plant itself is located in a area remote from the city.

The population in 1961 was estimated at 10,000. The treatment plant is designed for 25,000 people and an average design flow of 2.5 mgd (100 gals/cap/day). The treatment plant includes primary sedimentation, aeration, final sedimentation, chlorination and sludge digestion.

The facility was designed by Engineering Science and constructed by R. E. Ziebarth and S. B. Alper of Torrance, California. Construction was accomplished using local union labor. Neither weather nor site conditions had any real effect on the project.

The control building and appearance of the facility were adequate and functional.

Plant No. 3 - Hemet, California
SUMMARY OF DESIGN BASIS AND MAJOR EQUIPMENT SIZES

General Basis of Design

Design Population	25,000
Present Population	10,000
Average Design Flow	2.5 mgd
Hydraulic Design Flow	4.0 mgd
Design BOD Loading	250 mg/L 5,200 lbs/day
Design Suspended Solids Loading	300 MG/L 6,500 lbs/day

Treatment Facilities

Barminutor	
Number	One
Make	Chicago Pump
Sewage Pumps	
Number	Two
Type	Vertical, non-clog
Discharge, Maximum	3,100 gpm
Drive	Variable speed
HP	60
Primary Sedimentation Tanks	
Number of Units	Two
Flow	2.5 mgd
Volume	150,000 gallons
Detention Time	2.9 hours
Surface Area	1,970 sq.ft.
Design Overflow Rate	1,2000 gpd/sq.ft.
Weir Overflow Rate	14,000 gpd/ft.
Dimensions	
Length	125 ft.
Width	16 ft.
Depth	10 ft. SWD
Make	Walker
Aeration Basin	
Influent Flow	2.5 mgd
Recycle Rate	33 percent
Influent BOD	3,640 lbs/day
Detention Time	3.3 hours
Number of Basins	One
Total Volume	454,000 gals.
Dimensions	
Length	210 ft.
Width	24 ft.
Depth	12 ft.

Treatment Facilities (continued)

Blowers	
Number of Units	Two
Capacity each	3900 cfm
Make	Sutorbilt
Engines	
Number	Two
Type	Natural Gas
Final Sedimentation Tanks	
Flow	2.5 mgd
Recycle Rate	33 percent
Number of Units	Two
Total Volume	264,000 gallons
Total Surface Area	3,520 sq.ft.
Detention Time	1.9 hours
Design Overflow Rate	710 gpd/sq.ft.
Dimensions	
Length	110 ft.
Width	16 ft.
Depth	10 SWD
Make	Walker
Digestion Tanks	
Number	Two
Total Volume	692,000 gallons.
Gas Storage	15,750 cu.ft.
Detention Time	27 days @ 2.5 mgd.
Dimensions	
Diameter	50 ft.
SWD	21 ft.
Heating Boiler	
Number	One
Capacity	1,000,000 BTU
Gas Lifter	
Number	One
Capacity	11,000 gpm
	Eimco

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Table 5

Construction Cost Breakdown
Based on FWQA Cost Escalation Factor
Plant No. 3

PLANT: Water Reclamation Plant
LOCATION: Hemet-San Jacinto Valley, Calif.
PLANT CAPACITY: 2.5 MGD

ENGINEER: Engineering Science
LOCATION: Arcadia, Calif.
DATE OF BID 6-29-64

DESCRIPTION	COST	ESCALATE COST TO August 1, 1969 (FWQA) 1.24	ADJUST COST TO LOCATION (WASH. D.C.= 1.0) .93	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	15,000	18,600	17,298	6,920	1.8
SITE WORK-DEWATER					
CLEAR & GRUB					
LANDSCAPING	28,382	35,194	32,730	13,092	3.4
EXCAVATE & BACK.	32,450	40,238	37,421	14,969	3.9
CONCRETE ITEMS *	244,486	303,163	281,942	112,777	29.5
STRUCTURAL STEEL	45,000	55,800	51,894	20,758	5.4
CONTROL BUILDING	39,000	48,360	44,975	17,990	4.7
YARD PIPING					
MECHANICAL PIP'G	136,916	169,776	157,892	63,157	16.5
MECHANICAL EQUIP.*	154,623	191,733	178,312	71,325	18.7
ELECTRICAL	52,860	65,546	60,958	24,383	6.4
INSTRUMENTATION	40,000	49,600	46,128	18,451	4.8
SLUDGE HANDLING *	Included in mechanical equipment and concrete items.				
Misc.	39,173	48,574	45,174	18,070	4.9
TOTAL	827,890	1,026,584	954,724	381,892	100

MISC. ITEMS	
EMERGENCY POWER	
CFM/MGD	3200
HORSEPOWER	= 525

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Table 6

Construction Cost Breakdown
Based on ENR Cost Escalation Factor
Plant No. 3

PLANT: Water Reclamation Plant
LOCATION: Hemet-San Jacinto Valley
PLANT CAPACITY: 2.5 MGD

ENGINEER: Engineering Science
LOCATION: Arcadia, Calif.
DATE OF BID: 29 June 1964

DESCRIPTION	COST	ESCALATE COST TO DECEMBER 1, 1969 (ENR) 1.44	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) .834	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	15,000	19,470	16,238	6,495	1.8
SITE WORK-DEWATER					
CLEAR & GRUB					
LANDSCAPING	28,382	36,840	30,725	12,290	3.4
EXCAVATE & BACK.	32,450	42,120	35,128	14,051	3.9
CONCRETE ITEMS*	244,486	317,343	264,664	105,866	29.5
STRUCTURAL STEEL	45,000	58,410	48,714	19,487	5.4
CONTROL BUILDING	39,000	50,622	52,219	16,888	4.7
YARD PIPING					
MECHANICAL PIP'G	136,916	177,717	148,216	59,286	16.5
MECHANICAL EQUIP.*	154,623	200,700	167,384	66,954	18.7
ELECTRICAL	52,860	68,612	57,222	22,888	6.4
INSTRUMENTATION	40,000	51,920	43,301	17,320	4.8
SLUDGE HANDLING*	Included in mechanical equipment and concrete items.				
Misc.	39,173	50,847	42,406	16,962	4.9
TOTAL	827,890	1,074,601	896,217	358,487	100

MISC. ITEMS	
EMERGENCY POWER	
CFM/MGD	3200
HORSEPOWER	=525

Plant No. 4 - City of Denton, Texas

The City of Denton presently operates a 2 mgd conventional activated sludge plant and the City is currently in the process of expanding the facility to a 6 mgd plant. The plant is located in a sparsely populated residential area.

The estimated population of the City in 1967 was 36,000. Based on 100 gallons per capita per day, the 6 mgd facility would accommodate the City of Denton until 1979 when the population is expected to reach 59,800.

The treatment plant consists of primary clarification, aeration, final clarification, chlorination and wet air oxidation sludge disposal. The design loading for the system was 300 mg/L BOD_5 (15,000 lbs/day) and 340 mg/L suspended solids (17,000 lbs/day). The anticipated removals for the expanded facilities are 14,000 lbs/day of BOD and 16,000 lbs/day of suspended solids. The effluent, therefore, is expected to have no more than 20 mg/L of BOD and suspended solids; 2.5 mg/L of dissolved oxygen, and 1 mg/L chlorine residual after a 20-minute contact time.

All raw sewage entering the treatment plant is pumped into the primary clarifiers. An emergency gas engine is available to drive the largest pumping unit in the event of a power failure. Treated effluent from the plant is discharged into Pecan Creek, approximately two miles above its entrance into Garza-Little Elin Reservoir. The reservoir is located in the Trinity River Basin and serves as a municipal water supply for both the City of Dallas and the City of Denton.

Both the 2 mgd plant (which was placed in operation in 1964) and the 4 mgd expansion were designed by Freese, Nichols and Endress, Consulting Engineers of Fort Worth, Texas and constructed by Elm Fork Construction Company.

At the time of this survey, the expansion project was under construction. The weather up to this time had no effect on construction and no problems have been encountered. Work is being accomplished primarily with local non-union labor and the design engineer is providing construction surveillance. The facility has provisions for an office, garage, lab, etc., which appear quite functional and are probably inexpensive.

Five different contractors submitted bids, with base bids ranging from $34,964 to $210,220 above Elk Fork Construction Company's low bid.

Plant No. 4 - Denton, Texas

SUMMARY OF DESIGN BASIS AND MAJOR EQUIPMENT SIZES

General Basis of Design

Design Period	1979
Design Population	60,000
Average Design Flow[1]	6 mgd, (100 gals)capita/day)
Hydraulic Design Flow	18.5 mgd
Design BOD_5 Loading	0.25 lbs/capita/day
	15,000 lbs/day
Design Suspended Solids Loading	340 gpm

Treatment Facilities

Barminutor	
Make	Chicago Pump Company
Number of Units	One existing, plus one new
Structure	Existing, approximately 23 ft. deep
Raw Sewage Pumps	
No. 1	Southern Engine with Westinghouse Variable speed drive (existing)
No. 2	Southern Engine (existing)
No. 3	Southern Engine (existing)
No. 4	Smith Pump (new)
Pump Capacity	18.5 mgd

Grit Removal

Number of Units	One
Type	Aerated, w/basket elevator
Unit Area	14 ft. x 22 ft.
Design Overflow Rate	20,000 gpd/sq. ft.

Primary Clarifiers

Number of Units	Three (one existing)
Type	Center feed, peripheral overflow
Size	55 ft. diameter x 7 ft. SED
Detention Time	1.49 hours
Design Overflow rate	842 gpd/sq.ft.

[1]Existing plant capacity 2 mgd, plant to be expanded to 6 mgd

BOD removal	30 percent
Weir Overflow rate	11,574 gals/day/ft.
Type	Walker Process
Aeration Basins	
Number of Basins	Five (2 existing, 3 new)
Influent Flow	6 mgd
Recycle Rate	40 percent of flow
Influent BOD	10,500 lbs/day
Mixed Liquor Suspended Solids	35,000 lbs.
Detention time at 8.4 mgd	6.08 hours
Total capacity	2,125,000 gallons
Dimensions, each	
Length	144 ft.
Width	27 ft.
Depth	15 ft.
Aeration Equipment	
Diffusers	Swing type with carborundum tubes
Make	Chicago Pump
Number of Blowers	Five (2 existing, 3 new)
Capacity, each	2,500 cfm
Make	Roots Connerville (existing) Sutorbilt (new)
Design Capacity	1.67 cubic feet per gallon at 6 mgd
Final Clarifiers	
Number of Units	Three (one existing, two new)
Flow	6 mgd
Recycle Rate	40 percent
Make	Walker
Type	Center feed, peripheral overflow 65 ft. diameter x 12 ft. SWD (existing) 70 ft. diameter x 12 ft. SWD (new)
Total Volume	989,300 gd
Total Surface Area	11,008 sq.ft.
Detention time	2.82 hours
Design Surface Overflow Rate	
Weir Overflow Rate at 6 mgd	5,450 gals/day/ft.
Chlorine Contact Basin	
Flow	9 mgd
Detention Time	20 minutes
Volume	125,800 gallons

Dimensions

Length	60 ft.
Width	28 ft.
Depth	10 ft. SWD

Sludge Disposal

Anaerobic Digester (existing)
Unit to be coverted to holding tank when the Zimpro Wet-Air Oxidation, Sludge Disposal Unit is installed.

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Table 7

Construction Cost Breakdown
Based on FWQA Cost Escalation Factor
Plant No. 4 (Expansion)

PLANT: Sewage Treatment Plant (Expansion)
LOCATION: City of Denton, Texas
PLANT CAPACITY: 4.0 MGD

ENGINEER: Freese, Nichols & Endress
LOCATION: Fort Worth, Texas
DATE OF BID: 3-20-69

DESCRIPTION	COST	ESCALATE COST TO AUGUST 1, 1969 (FWQA) 1.0	ADJUST COST TO LOCATION (WASH. D.C.= 1.0) 1.11	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	--	--	--	--	--
SITE WORK-DEWATER	--	--	--	--	--
CLEAR & GRUB	--	--	--	--	--
LANDSCAPING	27,241	27,241	30,238	7,559	2.5
EXCAVATE & BACK.	60,957	60,957	67,662	16,916	5.5
CONCRETE ITEMS	254,033	254,033	281,977	70,494	23.2
STRUCTURAL STEEL	31,827	31,827	35,328	8,832	2.9
CONTROL BUILDING	61,774	60,774	68,569	17,142	5.6
YARD PIPING	146,553	146,553	162,674	40,669	13.4
MECHANICAL PIP'G	2,750	2,750	3,053	763	0.2
MECHANICAL EQUIP.	204,913	204,913	227,453	56,863	18.7
ELECTRICAL	30,180	30,180	33,500	8,375	2.8
INSTRUMENTATION	17,021	17,021	18,893	4,723	1.6
SLUDGE HANDLING	242,400	242,400	269,064	67,266	22.1
MISCELLANEOUS	16,825	16,825	18,676	4,669	1.5
TOTAL	1,096,474	1,096,474	1,217,087	304,271	100.0

MISC. ITEMS	
EMERGENCY POWER	Gas Engine
CFM/MGD	1667
HORSEPOWER	1015

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Table 8

Construction Cost Breakdown
Based on FWQA Cost Escalation Factor
Plant No. 4 (Existing)

PLANT: Sewage Treatment Plant (Existing Plant)*
LOCATION: City of Denton, Texas
PLANT CAPACITY: 2.0 MGD

ENGINEER: Freese, Nichols and Endress
LOCATION: Fort Worth, Texas
DATE OF BID: 1-3-62

DESCRIPTION	COST	ESCALATE COST TO AUGUST 1, 1969 (FWQA) 1.26	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) 1.11	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE					
SITE WORK-DEWATER					
CLEAR & GRUB					
LANDSCAPING					
EXCAVATE & BACK.					
CONCRETE ITEMS					
STRUCTURAL STEEL					
CONTROL BUILDING					
YARD PIPING					
MECHANICAL PIP'G					
MECHANICAL EQUIP.					
ELECTRICAL					
INSTRUMENTATION					
SLUDGE HANDLING		*Not included in survey			
TOTAL	575,833	725,550	805,360	402,680	
MISC. ITEMS					
EMERGENCY POWER					
CFM/MGD					
HORSEPOWER					

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Table 9

Construction Cost Breakdown
Based on ENR Cost Escalation Index
Plant No. 4 (Expansion)

PLANT: Sewage Treatment Plant (Expansion)
LOCATION: City of Denton, Texas
PLANT CAPACITY: 4.0 MGD

ENGINEER: Freese, Nichols and Endress
LOCATION: Fort Worth, Texas
DATE OF BID: 3-20-69

DESCRIPTION	COST	ESCALATE COST TO DECEMBER 1, 1969 (ENR) 1.09	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) 1.11	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	--	--	--	--	--
SITE WORK-DEWATER	--	--	--	--	--
CLEAR & GRUB	--	--	--	--	--
LANDSCAPING	27,241	29,693	32,959	8,240	2.5
EXCAVATE & BACK.	60,957	66,443	73,752	18,438	5.5
CONCRETE ITEMS	254,033	276,896	307,354	76,839	23.2
STRUCTURAL STEEL	31,827	34,691	38,507	9,627	2.9
CONTROL BUILDING	61,774	67,334	74,741	18,685	5.6
YARD PIPING	146,553	159,743	177,315	44,329	13.4
MECHANICAL PIP'G	2,750	2,997	3,326	831	0.2
MECHANICAL EQUIP.	204,913	223,355	247,924	61,981	18.7
ELECTRICAL	30,180	32,896	36,515	9,129	2.8
INSTRUMENTATION	17,021	18,553	20,594	5,148	1.6
SLUDGE HANDLING	242,400	264,216	293,280	73,318	22.1
MISCELLANEOUS	16,825	18,339	20,356	5,089	1.5
TOTAL	1,096,474	1,195,156	1,326,623	313,654	100.0
MISC. ITEMS					
EMERGENCY POWER	Gas Engine				
CFM/MGD	1667				
HORSEPOWER	1015 (estimated)				

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Table 10

Construction Cost Breakdown
Based on ENR Expansion Factor
Plant No. 4 (Existing)

PLANT: Sewage Treatment Plant (Existing)*
LOCATION: City of Denton, Texas
PLANT CAPACITY: 2.0 MGD

ENGINEER: Freese, Nichols and Endress
LOCATION: Fort Worth, Texas
DATE OF BID: 1-3-62

DESCRIPTION	COST	ESCALATE COST TO DECEMBER 1, 1969 (ENR)	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) 1.11	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE					
SITE WORK-DEWATER					
CLEAR & GRUB					
LANDSCAPING					
EXCAVATE & BACK.					
CONCRETE ITEMS					
STRUCTURAL STEEL					
CONTROL BUILDING					
YARD PIPING					
MECHANICAL PIP'G					
MECHANICAL EQUIP.					
ELECTRICAL					
INSTRUMENTATION					
SLUDGE HANDLING		*Not included in survey			
TOTAL	575,833	933,425	1,036,100	518,050	
MISC. ITEMS					
EMERGENCY POWER					
CFM/MGD					
HORSEPOWER					

Plant No. 5 - City of Titusville, Florida

The South Waste Treatment Plant of the City of Titusville is a 2-mgd facility which was designed by Black, Crow and Eidness and built by Cambron Construction Company, Inc. of Orlando Florida.

The rapid increase in population of Brevard County in the 1950's, which was due primarily to the construction and operation of America's most complete missile-testing laboratory, established Brevard County as the fastest growing county in the United States according to the National Aeronautics and Space Administration (NASA).

The plant is located on a 30-acre site near the Atlantic Ocean, with approximately 15 acres set aside for expansion. Construction began in September 1966 and was completed in April of 1968. It presently serves 7,000 people, but it was designed for approximately 14,000 people in the year 1985 (150 gal/cap/day). Design daily flow for 1985 is 2.0 mgd, and the design peak flow is 4.0 mgd. The chlorinated effluent is discharged to the ocean. Local unionized labor was used in construction, and the weather conditions were favorable for construction.

The treatment plant includes a comminutor, aeration tank, clarifiers, chlorination and sludge digestion. The design loading for the system is 200 mg/L of BOD and 32 mg/L of suspended solids, with removal efficiences expected to be 90 percent BOD and 92 percent suspended solids.

Five contractors submitted bids on 27 July 1966, with base bids ranging from $5,498 to $183,026 above the low bid.

Plant No. 5 - Titusville, Florida
SUMMARY OF DESIGN BASIS AND MAJOR EQUIPMENT SIZES

General Basis of Design

Design Period	1985
Design Population	14,000
Average Design Flow	2 mgd
Hydraulic Design Flow	4 mgd
Design BOD Loading	200 mg/L
Design Suspended Solids Loading	132 mg/L

Treatment Facilities

Comminutor	
Number of Units	One
Aeration Tank	
Number of Tanks	One
Influent Flow	2 mgd
Recycle Flow	100 percent
Detention Time	2.75 hours
Total Volume	62,000 cu. ft.
Dimensions	
Diameter	70 ft.
Depth	16 ft. SWD
Aeration Equipment	mechanical
Oxygen Required	5,100 lbs/day
Clarifiers	
Flow	2 mgd
Recycle Rate	100 percent
Number of Units	Two
Dimensions	
Diameter	50 ft.
Depth	10 ft. SWD
Chlorinator	400 lbs/hr.
Chlorine Contact Basin	
Flow	4 mgd
Length	40 ft.
Width	20 ft.
Depth	7.75 ft.
Contact Time	16 min.

Waste Sludge Pumps	
Number	Two
Capacity each	200 gpm
Sludge Recycle Pumps	
Number	Two
Capacity each	1,400 gpm
Sludge Digester	
Number	One
Dimensions	
Diameter	50 ft.
Depth	20 ft. SWD
Sludge Drying Beds	
Number	Four
Dimensions	50 ft. x 55 ft.

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Table 11

Consturction Cost Breakdown
Based on FWQA Cost Expansion Factor
Plant No. 5

PLANT: South Waste Treatment Plant
LOCATION: City of Titusville, Fla.
PLANT CAPACITY: 2.0 MGD

ENGINEER: Black Crow & Eidness
LOCATION: Gainsville, Fla.
DATE OF BID: 7-27-66

DESCRIPTION	COST	ESCALATE COST TO August 1 1969 (FWQA) 1.154	ADJUST COST TO LOCATION (WASH. D.C.= 1.0) 1.11	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	13,500	15,579	17,293	8,647	2.1
SITE WORK-DEWATER					
CLEAR & GRUB					
LANDSCAPING					
EXCAVATE & BACK.	55,000	63,470	70,452	35,226	8.5
CONCRETE ITEMS*	103,500	119,439	132,577	66,289	16.0
STRUCTURAL STEEL	19,500	22,503	24,978	12,489	3.0
CONTROL BUILDING	44,150	50,949	56,553	28,277	6.8
YARD PIPING					
MECHANICAL PIP'G	103,664	119,628	132,787	66,394	16.0
MECHANICAL EQUIP.	226,660	261,566	290,338	145,169	35.0
ELECTRICAL					
INSTRUMENTATION	82,000	94,628	105,037	52,519	12.6
SLUDGE HANDLING*	Included in	concrete items			
TOTAL	647,974	747,762	830,015	415,010	100

MISC. ITEMS	
EMERGENCY POWER	
CFM/MGD	
HORSEPOWER	

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Table 12

Construction Cost Breakdown
Based on ENR Cost Escalation Factor
Plant No. 5

PLANT: South Waste Treatment Plant
LOCATION: City of Titusville, Fla.
PLANT CAPACITY: 2.0 MGD

ENGINEER: Black, Crow & Eidness
LOCATION: Gainesville, Fla.
DATE OF BID 7-27-66

DESCRIPTION	COST	ESCALATE COST TO DECEMBER 1, 1969 (ENR)	ADJUST COST TO LOCATION (WASH. D.C.= 1.0)	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	13,500	17,820	19,780	9,890	2.1
SITE WORK-DEWATER		0			
CLEAR & GRUB					
LANDSCAPING					
EXCAVATE & BACK.	55,000	72,600	80,586	40,293	8.5
CONCRETE ITEMS	103,500	136,620	151,648	75,824	16.0
STRUCTURAL STEEL	19,500	25,740	28,571	14,285	3.0
CONTROL BUILDING	44,150	58,278	64,689	32,345	6.8
YARD PIPING					
MECHANICAL PIP'G	103,664	136,836	151,888	75,944	16.0
MECHANICAL EQUIP.	226,660	299,191	332,102	166,051	35.0
ELECTRICAL					
INSTRUMENTATION	82,000	108,240	120,146	60,073	12.6
SLUDGE HANDLING					
TOTAL	647,974	855,325	949,410	474,705	100

MISC. ITEMS	
EMERGENCY POWER	
CFM/MGD	
HORSEPOWER	

Plant No. 6 - City of Batavia, New York

Batavia is located in northwest New York State, approximately midway between Buffalo and Rochester. The City of Batavia presently operates a 2.5-mgd waste treatment plant, which was designed by Chester Engineers and constructed by William C. Pahl Construction Company, Inc. The facility was placed into operation in December of 1966. The plant is located within the City limits. The entrance to the plant is by way of a driveway from a typical city street. The plant is also visible from the main throughfare. The water pollution control plant consists of two comminutors, aeration tanks, clarifiers, chlorination facilities, a sludge thickener, sludge digesters and a vacuum filter.

In 1960, the U. S. Census Bureau reported the population of Batavia to be 18,210. The treatment plant was designed for the year 1987 when the population was expected to reach 25,000. An average flow of 100 gallons per capita per day was used as a design basis. The design loading for the plant was 6,000 lbs per day BOD and 3,800 lbs per day suspended solids, with removal efficiencies of 90 percent BOD and 80 percent suspended solids.

The aeration tanks are arranged to allow raw sewage to enter at either or both ends of each tank, and return sludge may be introduced into one end of each tank. After treatment, the effluent is discharged into the Tonawanda Creek.

Construction of the facility was planned such that all concrete and most work was accomplished prior to the winter season. The labor force mainly consisted of local unionized labor. The contractor experienced no great degree of trouble, with the exception of the mechanical equipment. This was due to his inexperience with this type of equipment. In fact, it was the contractor's first encounter with sewage treatment plant construction.

The facility's aethetic appearance is above average. The office, laboratory, shop area, garage, etc. had a quality finish, and they appeared to be spacious.

Ten bids were received for the general construction and base bids varied from $70,400 to $303,000 above the low bid.

Plant No. 6 - Batavia, New York
SUMMARY OF DESIGN BASIS AND MAJOR EQUIPMENT SIZES

General Basis of Design

Design Period	1987
Design Population	25,000
Average Design Flow	2.5 mgd
Peak Flow	6.25 mgd
Design BOD Loading	6,000 lbs/day
Design Suspended Solids Loading	3,800 lbs/day
Design Efficiency	
BOD Removal	90 percent
Suspended Soilds	80 percent

Treatment Facilities

Communutors	
Number of Units	Two
Capacity each	6.25 mgd
Aeration Tanks	
Number of Tanks	Two
Influent Flow	2.5 mgd
Recycle Flow	1 mgd
Detention Time	2 hours
BOD loading	73 lbs/1,000
Total Capacity	312,240 gallon or 41,632 cu.ft.
Channels	Two
Dimensions per channel	
Length	64 ft.
Width	23 ft.
Depth	15 ft. (max.)
Instrumentation	
Influent	Two - 14" magnetic meters
Sludge	Two - 4" magnetic meters
Blowers	
Type	Positive displacement
Size	One electric driven - 2,900 cfm, One electric driven - 3,700 cfm, One gas engine 2,800-3,500 cfm.
Sedimentation Tanks	
Influent Flow	2.5 mgd
Number of Tanks	Two
Detention Time	2.5 hours

Design Surface Overflow Rate	885 gals/sq.ft./day
Weir Length	608 ft.
Dimensions	
Diameter	45 ft.
Depth	10 ft. SWD

Chlorine Contact Tanks

Maximum Flow	6.25 mgd
Detention Time	15 minutes
Total Capacity	33,000 gallons
Number of Tanks	Two
Dimensions	
Length	21 ft.
Width	21 ft.
Depth	10 ft. SWD

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Table 13

Construction Cost Breakdown
Based on FWQA Cost Escalation Factor
Plant No. 6

PLANT: Water Pollution Control Plant
LOCATION: Batavia, New York
PLANT CAPACITY: 2.5 MGD

ENGINEER: Chester Engineers
LOCATION: Pittsburgh, Pa.
DATE OF BID 3-5-64

DESCRIPTION	COST	ESCALATE COST TO AUGUST 1, 1969 (FWQA) 1.21	ADJUST COST TO LOCATION (WASH. D.C.= 1.0) .89	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	10,600	12,826	11,415	4,566	0.9
SITE WORK-DEWATER	--	--	--	--	--
CLEAR & GRUB	8,700	10,527	9,369	3,747	0.7
LANDSCAPING	19,100	23,111	20,569	8,227	1.6
EXCAVATE & BACK.	76,100	92,081	81,952	32,780	6.3
CONCRETE ITEMS	324,600	392,766	349,561	139,824	26.9
STRUCTURAL STEEL	55,725	67,427	60,010	24,004	4.6
CONTROL BUILDING	173,729	210,212	187,088	74,835	14.4
YARD PIPING	16,080	19,457	17,317	6,926	1.4
MECHANICAL PIP'G	179,332	216,992	193,123	77,249	14.9
MECHANICAL EQUIP.	232,124	280,870	249,974	99,990	19.2
ELECTRICAL	49,240	59,580	53,026	21,210	4.1
INSTRUMENTATION	20,500	24,805	22,076	8,830	1.7
SLUDGE HANDLING	40,200	48,642	43,291	17,316	3.3
TOTAL	1,206,030	1,459,296	1,298,771	519,504	100.0

MISC. ITEMS	
EMERGENCY POWER	Gas Engine
CFM/MGD	2400
HORSEPOWER	430

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Table 14

Construction Cost Breakdown
Based on ENR Escalation Factor
Plant No. 6

PLANT: Water Pollution Control Plant
LOCATION: Batavia, New York
PLANT CAPACITY: 2.5 MGD

ENGINEER: Chester Engineers
LOCATION: Pittsburgh, Pa.
DATE OF CONSTRUCTION 3-5-64

DESCRIPTION	COST	ESCALATE COST TO DECEMBER 1, 1969 (ENR) 1.32	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) .769	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	10,600	13,992	10,759	4,303	0.9
SITE WORK-DEWATER	--	--	--	--	--
CLEAR & GRUB	8,700	11,484	8,831	3,533	0.7
LANDSCAPING	19,100	25,212	19,388	7,755	1.6
EXCAVATE & BACK.	76,100	100,452	77,248	30,899	6.3
CONCRETE ITEMS	324,600	428,472	329,495	131,798	26.9
STRUCTURAL STEEL	55,725	73,557	56,565	22,626	4.6
CONTROL BUILDING	173,729	229,322	176,349	70,540	14.4
YARD PIPING	16,080	21,226	16,323	6,529	1.4
MECHANICAL PIP'G	179,332	236,718	182,036	72,814	14.9
MECHANICAL EQUIP.	232,124	306,403	235,624	94,250	19.2
ELECTRICAL	49,240	64,997	49,983	19,993	4.1
INSTRUMENTATION	20,500	27,060	20,809	8,324	1.7
SLUDGE HANDLING	40,200	53,064	40,806	16,322	3.3
TOTAL	1,206,030	1,591,959	1,224,216	489,686	100.0
MISC. ITEMS					
EMERGENCY POWER					
CFM/MGD	2400				
HORSEPOWER	430				

Plant No. 7 - Town of Lee, Massachusetts

The Town of Lee, Massachusetts presently operates a 1.0-mgd activated sludge treatment plant as designed by Bowe, Albertson and Walsh Engineers of New York, New York. The facility was built by C. H. Nickerson and Company, Inc. of Torrington, Connecticut.

The town is located in the Housatonic Valley in the western part of Massachusetts, approximately fifteen miles south of the City of Pittsfield. The topography is rugged and broken by numerous brooks. The treatment plant is located on municipally-owned property along the Housatonic River, approximately 4,000 feet south of the Massachusetts Turnpike and east of Route 102. The plant effluent is discharged to the Housatonic River.

The plant is designed for the year 1981 (15-year design period) and a population of 8,000. It is anticipated that industrial waste and infiltration would each contribute 0.1 mgd, or a total flow (including domestic sewage) of 10 mgd. An average flow of 100 gallons per capita per day of domestic sewage was used as a design basis.

The major units comprising the treatment plant are a comminutor, grit chambers, raw sewage pump station, aeration tanks, secondary settling tanks, chlorination facilities, aerobic sludge digester, sludge drying beds, and a control and equipment building. The overall treatment plant appearance is excellent and appears to be of high quality engineering and construction.

The Engineer's original cost estimate in June 1966 for this project was $745,000. Three bids were received for the general construction, and base bids varied from $30,106 to $40,475 above the low bid.

Plant No. 7 - Lee, Massachusetts
SUMMARY OF DESIGN BASIS AND MAJOR EQUIPMENT SIZES

General Basis of Design

Design Period	1981
Design Population	8,000
Average Design Flow	
Domestic	0.8 mgd
Commercial and Industrial	0.1 mgd
Infiltration	0.1 mgd
Maximum Flow Rate	2.5 mgd

Treatment Facilities

Comminuting Chamber	
Comminutor Size	24"
Flow	6.5 mgd
Aerated Grit Chamber	
Flow	2.5 mgd
Detention Time	3.75 minutes
Dimensions	
Length	14 ft
Width	6 ft
Depth	10 ft
Air Supply	43.5 cfm
Wet Well	
Length	27 ft
Width	9 ft
Raw Sewage Pumps	
Number of Units	Four
Type	Horizontal, Non-clog
Aeration Tanks	
Influent Flow	1 mgd
Recycle Rate	
Influent BOD	1800 lbs.
Number of Tanks	Four
Dimensions each	
Length	125 ft
Width	15 ft
Depth	12 ft SWD
Total Volume	90,000 cu.ft.
Detention Time	16.2 hrs. @ 1 mgd
Air Requirements	1 cfm/16 BOD
Blowers	
Number of Units	Two
Capacity each	2,250 cfm

Secondary Settling Tanks	
Maximum Flow Rate	2.5 mgd
Number of Tanks	Two
Total Volume	24,960 cu.ft.
Detention Time	4.48 hrs@1 mgd
Total Area Required	3,120 sq. ft.
Design Overflow Rate	800 gals/day/sq.ft.
Weir Length	160 ft.
Weir Overflow Rate	6,250 gals/day/ft.
Dimensions	
Length	78 ft.
Width	20 ft.
Depth	8 ft. SWD
Sludge Recycle Pumps	
Number	Two
Control	2 speed
Flow Rate	350 to 1,520 GPM
Chlorine Contact Basin	
Flow	2.5 mgd
Detention Time	15 minutes
Total Volume	3,528 cu. ft.
Dimensions	
Length	28 ft.
Width	18 ft.
Depth	7 ft. SWD
Aerobic Digester	
Number of Tanks	Two
Total Capacity	9,000 cu.ft.
Detention Time	6.5 days
Influent Sludge Concentration	0.5 percent
Under Flow Concentration	2.0 percent
Air Required	600 cfm
Dimensions	
Length	25 ft.
Width	15 ft.
Depth	12 ft. SWD
Sludge Drying Beds	
Number	Three
Total Area	2,250 sq. ft.
Dimensions	
Length	37.5 ft.
Width	20 ft.

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Table 15

Construction Cost Breakdown
Based on FWQA Cost Escalation Factor
Plant No. 7

PLANT: Sewage Treatment Plant
LOCATION: Lee, Massachusetts
PLANT CAPACITY: 1.0 MGD

ENGINEER: Bowe, Albertson Walsh
LOCATION: N.Y.C., Melville, N.Y.
DATE OF BID: 1-9-67

DESCRIPTION	COST	ESCALATE COST TO AUGUST 1, 1969 (FWQA) 1.222	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) .98	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	42,407	51,821	50,785	50,785	5.5
SITE WORK-DEWATER	43,000	52,546	51,495	51,495	5.6
CLEAR & GRUB	500	611	599	599	-
LANDSCAPING	26,932	32,911	32,253	32, 253	3.5
EXCAVATE & BACK.	32,615	39,855	39,058	39,058	4.2
CONCRETE ITEMS	192,882	235,702	230,988	230,988	25.0
STRUCTURAL STEEL	45,453	55,544	54,433	54,433	5.9
CONTROL BUILDING	73,502	89,819	88,023	88,023	9.5
YARD PIPING	3,661	4,474	4,385	4,385	0.5
MECHANICAL PIP'G	76,500	93,483	91,613	91,613	9.9
MECHANICAL EQUIP.	147,910	180,746	177,131	177,131	19.1
ELECTRICAL	74,500	91,039	89,218	89,218	9.7
INSTRUMENTATION	12,000	14,664	14,371	14,371	1.6
SLUDGE HANDLING*	Included	in concrete items			
TOTAL	771,862	954,215	925,352	924,352	100
MISC. ITEMS					
EMERGENCY POWER					
CFM/MGD					
HORSEPOWER					

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Table 16

Construction Cost Breakdown
Based on ENR Cost Escalation Factor
Plant No. 7

PLANT: Sewage Treatment Plant
LOCATION: Lee, Mass
PLANT CAPACITY: 1.0 MGD

ENGINEER: Bowe, Albertson Walsh
LOCATION: N.Y.C. Melville, N.Y.
DATE OF BID: 1-9-67

DESCRIPTION	COST	ESCALATE COST TO DECEMBER 1, 1969 (ENR) 1.235	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) .94	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	42,407	52,373	49,230	49,230	5.5
SITE WORK-DEWATER	43,000	53,105	49,918	49,918	5.6
CLEAR & GRUB	500	618	580	580	-
LANDSCAPING	26,932	33,261	31,265	31,265	3.5
EXCAVATE & BACK.	32,615	40,280	37,863	37,863	4.2
CONCRETE ITEMS*	192,882	238,209	223,916	223,916	25.0
STRUCTURAL STEEL	45,453	56,134	52,766	52,766	5.9
CONTROL BUILDING	73,502	90,775	85,328	85,328	9.5
YARD PIPING	3,661	4,521	4,250	4,250	0.5
MECHANICAL PIP'G	76,500	94,478	88,810	88,810	9.9
MECHANICAL EQUIP.	147,910	182,669	171,710	171,710	19.1
ELECTRICAL	74,500	92,008	86,488	86,488	9.7
INSTRUMENTATION	12,000	14,820	13,930	13,930	1.6
SLUDGE HANDLING *	Included in concrete items				
TOTAL	771,862	953,251	896,054	896,054	100
MISC. ITEMS					
EMERGENCY POWER					
CFM/MGD					
HORSEPOWER					

Plant No. 8 - Beaver Brook District, City of Milford, Connecticut

The City of Milford has a 3.1-mgd sewage treatment plant which can be operated as either an extended aeration or an activated sludge plant. The plant was engineered by Metcalf and Eddy of Boston, Massachusetts and built by L. G. Defelice and Son, Inc., of North Haven, Connecticut.

The plant is expected to begin operation in 1970, to serve a population of 4,500. The design year and population are 1990 and 21,000, respectively, with an average daily flow of 120 gallons per capita per day. By 1990, it is expected that industrial wastes will add another 0.6 mgd, for a total daily plant flow of 3.1 mgd.

The plant was constructed on approximately six acres of land and it provides primary and secondary treatment of wastewaters with separate sludge digestion, vacuum filtration, and chlorination. Secondary treatment consists of the standard rate activated sludge and standard rate digestion processes.

The facility has the capacity for a peak flow of 9.3 mgd. Space is available and certain structures (lift station, aerated grit chamber) are sized for increasing the average flow to 6.2 mgd and the peak flow of 15.5 mgd.

The Contractor encountered some difficulties on the project due mainly to his inexperience in constructing sewage treatment plants. Local unionized labor was used in construction.

Although incomplete at the time of the survey, the facility appeared to have an excellent aesthetic appearance. The control building was quite elaborate, with above average quality.

The engineer's estimate for construction of the plant was $2,060,000. Four bids were received, with base bids varying from $170,000 to $300,000 above the low bid.

Plant No. 8 - Milford, Connecticut
SUMMARY OF DESIGN BASIS AND MAJOR UNIT SIZES

General Basis of Design

Design Period	1990
Design Population	21,000
Average Design Flow	3.1 mgd
Peak Flow	9.3 mgd
Municipal Waste	
Average daily flow	120 gals/capita/day
Flow	2.5 mgd
Design BOD_5 loading	0.17 lbs/capita/day
Design Suspended Solids	0.20 lbs/capita/day
Industrial Waste	
Flow	0.6 mgd
Design BOD_5	250 mg/L
Design Suspended Solids	300 mg/L
Total Design BOD Loading	4,800 lbs/day
Total Design S.S. Loading	5,700 lbs/day

Treatment Facilities

Comminutor	
Number of Units	Two
Size	2.5"
Capacity	9.3 mgd
Flow Measuring	
Type	Parshall Flume
Size	18"
Flow	0.5 to 10 mgd
Lift Station	
Number of Pumps	Four (2 constant speed, 2 variable speed)
Capacity	9.3 mgd
Grit Chamber	
Number of Chambers	Two
Detention Time at Peak Flow	5.1 minute
Air Supply	3 - 6 cfm/ft
Dimensions	
Length	18.5 ft
Width	12.5 ft
Depth	9.5 ft

Primary Tanks	
Flow	3.1 mgd
Number of Tanks	Two
Detention Time	2 hours
Design Surface Overflow Rate	695 gals/sq. ft./day
Dimensions	
Length	111.5 ft
Width	20 ft
Depth	7.75 ft SWD
Aeration Tanks	
Influent Flow	3.1 mgd
Recycle Rate (max.)	1.6 mgd
Mixed Liquor Solids	2,000 mg/L
BOD Loading	3,360 lbs./day
Number of Tanks	Two
Detention Time	6 hours
Dimensions	
Length	137.5'
Width	25'
Depth	15'
Blowers	
Number of Blowers	Two
Total Air Required	3,750 cfm
Number of Units in Operation	one (one stand-by)
Final Settling Tanks	
Number of Tanks	Two
Detention Time	2.9 hours
Surface Overflow Rate	620 gal./sq. ft./day
Dimensions	
Length	125 ft
Width	20 ft
Depth	10 ft SWD
Chlorination System	
Number of Units	Two
Feed	In Outfall Sewer
Detention Time	36 minutes
Feed Rate at 8 mg/L avg. flow	207 lbs./day
Sludge Digestion Tanks	
Total Digestion Volume	113,300 cu. ft.
Equivalent S.S. Population	28,500
Suspended Solids Volume	4.0 cu ft/capita
Primary Digestion Tanks	
Number of Tanks	One
Diameter	55 ft
Depth	29 ft SWD
Volume	60,200 cu. ft.
Solids	5,400 lbs./day

Primary Digestion Tanks (continued)

Sludge Feed	16,200 gals/day
Concentration	4 percent
Volatile Solids	4,050 lb/day
Detention Time	27.8 days
Type Cover	Fixed Steel
Type Mixing	Gas Recirculation

Secondary Digesting Tanks

Number of Tanks	One
Diameter	26 ft. SWD
Depth	53,100 cu.ft.
Volume	Floating
Cover	Gasholder

Sludge Dewatering

Type	Vacuum Filter
Number	One
Area	250 sq.ft.
Capacity	3 lbs/sq.ft./hr.
Total Dry Solids	21,000 lbs/wk.

Sludge Elutriation

Number of Tanks	One
Diameter	40 ft.
Depth	10 ft. SWD
Surface Area	1257 sq.ft.
Overflow Rate	8.95 gals/sq.ft./hr.

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Table 17

Construction Cost Breakdown
Based on FWQA Cost Escalation Factor
Plant No. 8

PLANT: Beaver Brook District Sewage Treatment Plant
LOCATION: Milford, Connecticut
PLANT CAPACITY: 3.1 MGD

ENGINEER: Metalf and Eddy, Inc.
LOCATION: Boston, Mass.
DATE OF BID: 2-13-68

DESCRIPTION	COST	ESCALATE COST TO AUGUST 1, 1969 (FWQA) 1.11	ADJUST COST TO LOCATION (WASH. D.C.= 1.0) .98	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	155,000	172,050	168,609	54,390	5.8
SITE WORK-DEWATER					
CLEAR & GRUB	472,500	524,475	513,986	165,802	17.7
LANDSCAPING	43,750	48,563	47,592	15,352	1.6
EXCAVATE & BACK.	74,700	82,917	81,259	26,213	2.8
CONCRETE ITEMS	468,500	520,035	509,634	164,398	17.5
STRUCTURAL STEEL	116,700	129,537	126,946	40,950	4.4
CONTROL BUILDING	533,250	591,908	580,070	187,119	19.9
YARD PIPING	209,700	232,767	228,117	73,586	7.9
MECHANICAL PIP'G	82,100	91,131	89,308	28,809	3.1
MECHANICAL EQUIP.	224,600	249,306	244,320	78,813	8.4
ELECTRICAL	118,500	131,535	128,904	41,582	4.4
INSTRUMENTATION	92,500	102,675	100,622	32,459	3.5
SLUDGE HANDLING	74,000	82,140	80,497	25,967	2.8
MISCELLANEOUS	4,200	4,662	4,569	1,474	0.2
TOTAL	2,670,000	2,963,701	2,904,433	936,914	100
MISC. ITEMS					
EMERGENCY POWER					
CFM/MGD					
HORSEPOWER					

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Table 18

Construction Cost Breakdown
Based on ENR Cost Escalation Factor
Plant No. 8

PLANT: Beaver Brook STP
LOCATION: Milford, Connecticut
PLANT CAPACITY: 3.1 MGD

ENGINEER: Metcalf and Foot Inc.
LOCATION: Boston, Mass.
DATE OF BID: 2-13-68

DESCRIPTION	COST	ESCALATE COST TO DECEMBER 1, 1969 (ENR) 1.18	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) .94	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	155,000	182,900	171,926	55,446	5.8
SITE WORK-DEWATER					
CLEAR & GRUB	472,500	557,550	524,097	169,021	17.7
LANDSCAPING	43,750	51,625	48,527	15,650	1.6
EXCAVATE & BACK.	74,700	88,146	82,857	26,721	2.8
CONCRETE ITEMS	468,500	552,830	519,660	167,590	17.5
STRUCTURAL STEEL	116,700	137,706	129,444	41,746	4.4
CONTROL BUILDING	553,250	629,235	591,481	190,753	19.9
YARD PIPING	209,700	247,446	232,599	75,013	7.9
MECHANICAL PIP'G	82,100	96,878	91,066	29,369	3.1
MECHANICAL EQUIP.	224,600	265,028	249,126	80,343	8.4
ELECTRICAL	118,500	139,830	131,440	42,389	4.4
INSTRUMENTATION	92,500	109,150	102,601	33,089	3.5
SLUDGE HANDLING	74,000	87,320	82,081	26,471	2.8
MISCELLANEOUS	4,200	4,956	4,659	1,503	0.2
TOTAL	2,670,000	3,150,600	2,961,564	955,104	100
MISC. ITEMS					
EMERGENCY POWER					
CFM/MGD					
HORSEPOWER					

Plant No. 9 - Town of East Windsor, Connecticut

The Town of East Windsor operates an 0.8-mgd conventional sludge treatment plant. The facility was built by C. H. Nickerson and Company, Inc. of Torrington, Connecticut and designed by Buck and Buck Engineers of Hartford, Connecticut.

The plant is located on a section of the 22-acre site which the Town has acquired near the mouth of Blue Ditch, north of Highway I-91. The effluent from the plant discharges to the Connecticut River.

The plant was designed for a twenty-year population growth and is expected to serve approximately 7,950 people in the year 1988. An average flow of 100 gallons per capita per day was used as a design basis. The ultimate population of the Town for the year 2010 is estimated at 70,250. This figure was used for sizing trunk line sewers and important mains.

The facility includes a lift station, primary clarifiers, aeration tanks, a secondary sedimentation tank, a chlorine contact tank, digesters, a sludge thickener, and a centrifuge. The plant is designed so that the capacity may be easily doubled by increasing tankage as required and by utilizing space within the original buildings. The engineer also provided the plant with a holding tank to receive the contents of septic tank trucks. The engineer's original estimate for the waste treatment plant was approximately $450,000 in June 1967.

The treatment plant gives an overall appearance of high quality engineering and construction. The control building is quite modern and expensively furnished.

Weather conditions during construction were normal for this area, while labor consisted of mainly local unionized workers.

Three contractors submitted bids for construction of the treatment plant. Two of the bids exceeded the base bid by $246,490 and $289,100, respectively.

Plant No. 9 - East Windsor, Connecticut

SUMMARY OF DESIGN BASIS AND MAJOR EQUIPMENT SIZES

General Basis of Design

Design Period	1988
Design Population	7950
Average Design Flow	0.8 mgd (100 gals/capita/day)
Hydraulic Design Flow	2.4 mgd

Treatment Facilities

Primary Clarifiers	
Flow	0.8 mgd
Number of Clarifiers	Two
Total Volume	9,900 cu.ft.
Detention Time	2.22 hours
Total Area	1000 sq.ft.
Design Surface Overflow Rate	600 gals/day/sq.ft.
Weir Overflow Rate	2,125 gals/day/ft.
Dimensions	
Diameter	30 ft.
Depth	7 ft. SWD
Aeration Tanks	
Influent flow	0.8 mgd
Recycle Rate	30 percent
Mixed Liquor Suspended Solids	2500 mg/L
Influent BOD concentration	200 mg/L
Detention Time	5 hours
Number of Tanks	Two
Total Volume	29,000 cu.ft.
Dimensions	
Length	100 ft.
Width	15 ft.
Depth	10 ft.
Oxygen Requirements	723.6 cfm

Treatment Facilities (continued)

Secondary Sedimentation Tank	
Flow	0.8 mgd
Recycle Rate	30 percent
Number of Tanks	One
Total Volume	4,949 cu.ft.
Detention Time	1,704 hours
Design Surface Overflow Rate	800 gals/sq.ft./day
Weir Overflow Rate	5,500 gals/ft./day
Weir Length	94.2 ft.
Dimensions	
Diameter	30 ft.
Depth	7 ft. SWD
Chlorine Contact Tank	
Maximum Flow	2.4 mgd
Detention Time	15 minutes
Total Volume	3,340 cu.ft.
Size	5' x 8' x 83.5'
Digesters	
Design Population	8,000
Volume Per Capita	5.0 - 20 for heated tank = 4.0 cu.ft./capita
	6.0 - 20 for unheated tank = 4.8 cu.ft./capita
Number of Tanks	Two
Total Volume	35,000 cu.ft.
Dimensions	
Diameter	30 ft.
Depth	23' - 6" SWD
Vacuum Filter	
Total Suspended Solids	1,335 lbs/day
Solids Load to Digester	1,200 lbs/day
Daily Digested Sludge Production	720 lbs/day
Filter Capacity	5 lbs/hr/sq.ft.
Filter Area	100 sq.ft.
Hourly Capacity	500 lbs/hr.

Note: Centrifuge installed in place of Vacuum Filter

Sludge Thickener	
Influent Flow	80 GPM
Design Solids Loading	6.75 lbs/sq.ft/day
Area Required	178 sq.ft.
Overflow Rate	650 gals/sq.ft./day
Dimensions	
Diameter	15 ft.
Depth	10 ft. SWD

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Table 19

Construction Cost Breakdown
Based on FWQA Cost Escalation Factor
Plant No. 9

PLANT: Sewage Treatment Plant
LOCATION: E. Windsor, Connecticut
PLANT CAPACITY: 0.8 MGD

ENGINEER: Buck and Buck
LOCATION: Hartford, Conn.
DATE OF BID: 7-29-68

DESCRIPTION	COST	ESCALATE COST TO AUGUST 1 1969 (FWQA) 1.11	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) .98	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	97,492	108,216	106,052	132,565	9.6
SITE WORK-DEWATER	20,500	22,755	22,300	27,875	2.0
CLEAR & GRUB	2,000	2,220	2,176	2,720	0.2
LANDSCAPING	10,161	11,279	11,053	13,816	1.0
EXCAVATE & BACK.	47,193	52,384	51,336	64,170	4.7
CONCRETE ITEMS	204,270	226,740	222,205	277,756	20.1
STRUCTURAL STEEL	62,000	68,820	67,444	84,305	6.1
CONTROL BUILDING	100,186	111,207	108,983	136,229	9.9
YARD PIPING	11,799	13,098	12,836	16,045	1.2
MECHANICAL PIP'G	*116,957	129,823	127,227	159,034	11.5
MECHANICAL EQUIP*	273,805	303,924	297,846	372,308	27.0
ELECTRICAL	67,852	75,316	73,810	92,263	6.7
INSTRUMENTATION					
SLUDGE HANDLING	* Incl.				
TOTAL	1,014,217	1,125,782	1,103,268	1,379,086	100

MISC. ITEMS	
EMERGENCY POWER	
CFM/MGD	
HORSEPOWER	

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Table 20

Construction Cost Breakdown
Based on ENR Cost Escalation Factor
Plant No. 9

PLANT: Sewage Treatment Plant
LOCATION: East Windsor, Connecticut
PLANT CAPACITY: .8 MGD

ENGINEER: Buck and Buck
LOCATION: Hartford, Connecticut
DATE OF BID: 7-29-68

DESCRIPTION	COST	ESCALATE COST TO DECEMBER 1, 1969 (ENR) 1.12	ADJUST COST TO LOCATION (WASH. D.C. = 1.0) .94	DOLLARS PER MGD	PERCENT OF TOTAL
MOVE & MOBILIZE	97,492	109,192	102,640	128,300	9.6
SITE WORK-DEWATER	20,500	22,960	21,582	26,978	2.0
CLEAR & GRUB	2,000	2,240	2,106	2,633	.2
LANDSCAPING	10,161.34	11,380	10,697	13,371	1.0
EXCAVATE & BACK.	47,193.10	52,856	49,685	62,106	4.7
CONCRETE ITEMS	204,270	228,782	215,055	268,819	20.1
STRUCTURAL STEEL	62,000	69,440	65,274	81,592	6.1
CONTROL BUILDING	100,186.71	112,209	105,476	131,845	9.9
YARD PIPING	11,799.75	13,216	12,423	15,529	1.2
MECHANICAL PIP'G	116,957.36	130,992	123,132	153,915	11.5
MECHANICAL EQUIP.	273,805.43	306.662	288,263	360,329	27.0
ELECTRICAL	67,852.09	75,994	71,434	89, 292	6.7
INSTRUMENTATION					
SLUDGE HANDLING	Incl. with Equip. Centrifuge and Flocc. System				
TOTAL	1,014,217.78	1,135,923	1,067,767	1,334,709	100

MISC. ITEMS	
EMERGENCY POWER	
CFM/MGD	
HORSEPOWER	

SUMMARY OF TREATMENT PLANT COSTS

The following series of tables summarizes the comparison of the construction costs of the various treatment plants. Table 21 shows the costs of the individual plants based on dollars per mgd corrected for time and location. This table also indicates average and median values, as well as the range of the costs. In Table 22, the construction costs per mgd have been rearranged in the order of least cost first.

Table 23 is a cost data matrix for each of the major construction cost categories for each treatment plant expressed in dollars per mgd. This table also provides an allowance for special items which has been deducted from the total cost of each plant. These deductions reflect costs that may be peculiar to a particular site i.e. land conditions (Deduction A) or for a special high cost item such as a lift station (Deduction B).

Table 24 is a comparison of the costs based on hydraulic capacity.

The data obtained from the nine sewage treatment plants involved in the regional sampling program indicate an average cost per mgd (corrected for time and location) of $629,269 with a range of values between $313,654 (Plant 4) to $1,334,709 (Plant 9). It is important to note that Plant 4 represents a plant expansion, and since it was less expensive to construct this expansion than to build a new facility, this plant should not be considered in this comparison. Therefore, the range of values in terms of cost per mgd varies from $358,478 (Plant 3) to $1,334,709 (Plant 9), for a spread of $976,222.

Certain items in the cost of a plant may be peculiar to a location, land conditions or contractor location, such as move and mobilize, dewatering, clearing and grubbing and landscaping. By deducting these items (Deduction A) from each plant, the difference in costs would be $823,725.

Another major item in treatment cost is a sewage lift station. The lift station would also influence the concrete and steel category, which would further reduce the difference in costs. The cost of Plants 1, 2, 3, 4 and 6 do not include this item, while Plant 5, 7, 8 and 9 reflect this cost. An analysis of

Table 21

Summary of Treatment Plant Costs Per mgd

Plant Group	Plant No.	Cost/mgd
Control Plants	1	$ 470,402
	2	370,620
	3	358,487
	4	313,654
	5	474,705
Northeast Region Plants	6	489,686
	7	896,054
	8	955,104
	9	1,334,709
	TOTAL	$5,663,421
	AVERAGE	$ 629,269
	MEDIAN	$ 474,705
	MODE	$ 470,402 to $ 489,686
	RANGE	$ 313,654 to $1,334,709

Table 22

Summary of Treatment Plant Cost Per mgd
Arranged in Series of Increasing Cost

Plant No.	Cost/mgd
4	$ 313,654
3	358,487
2	370,620
1	470,402
5	474,705
6	489,686
7	896,054
8	955,104
9	1,334,709
TOTAL	$5,663,421

Table 23

Data Matrix of Treatment Plant Costs
Dollars Per mgd[1]

Description	1	2	3	4[2]		5	6	7	8	9
Move and Mobilize	$ 5,813	$ 4,050	$ 6,495	-		$ 9,890	$ 4,303	$ 49,230	$ 55,446	$ 128,300
Dewater	311	4,303	-	-		-	-	49,918	-	26,978
Clear and Grub	7,890	2,684	-	-		-	3,533	580	169,021	2,633
Landscape	5,294	10,455	12,290	$ 8,240		-	7,755	31,265	15,650	13,371
Excavate and Back	12,042	10,734	14,051	18,438		40,293	30,899	37,863	26,721	62,106
Concrete Items	91,002	80,168	105,866[3]	76,839		75,824[3]	131,798	223,916[3]	167,590	268,819
Structural Steel	12,458	8,978	19,487	9,627		14,285	22,626	52,766	41,746	81,592
Control Build.	15,572	34,479	16,888	18,685		32,345	70,540	85,328	190,753	131,845
Yard Piping	51,387	34,952	59,286	44,329		75,944	6,529	4,250	75,013	15,529
Mechanical Piping	1,495	14,480		831			72,814	88,810	29,369	153,915
Mechanical Equipment	81,333	62,630	66,954[3]	61,981		166,051	94,250	171,710	80,343	360,329[3]
Electrical	44,847	13,543	22,888	9,129		60,073	19,993	86,488	42,389	89,292
Instrumentation	27,822	17,594	17,320	5,148			8,324	13,930	33,089	-
Sludge Handling	108,172	63,017	-	73,318		-	16,322	-	26,471	-
Painting	-	-	-	5,089		-	-	-	-	-
Miscellaneous	4,964	8,544	16,962	-		-	-	-	1,503	-
TOTAL	$470,402	$370,620	$358,487	$313,654	$518,050	$474,705	$489,686	$896,054	$955,104	$1,334,709
Deduction A	19,908	21,492	18,758	-	-	9,890	15,591	130,993	240,117	171,282
Total	450,494	349,128	339,702	-	-	464,815	474,095	765,061	714,987	1,163,427
Deduction B	12,042	10,734	14,051	-	-	40,293	30,899	37,863	26,721	62,106
Total	$438,452	$338,394	$325,651	-	-	$424,522	$443,196	$727,198	$688,266	$1,101,321

[1]Based on ENR cost expansion factor.
[2]Cost of existing facilities only.
[3]Includes sludge handling equipment

Table 24

Cost Comparisons Based
On Hydraulic Capacity

Plant	Design Flow	Hydraulic Flow	Cost/mgd	Cost (less Deduction A and Deduation B)
1	4.0	8.0	263,281	219,226
2	4.0	-	-	-
3	2.5	4.0	238,681	211,496
4[1]	6.0	18.5	-	-
5	2.0	4.0	207,504	212,261
6	2.5	6.25	207,803	177,278
7	1.0	2.5	369,741	290,879
8	3.1	9.3	312,304	227,422
9	0.8	2.4	574,620	367,107

[1]Includes both existing and expanded plant.

the excavate and backfill items shows that four of the five highest costs in this category contained an allowance for lift stations. By deducting this item (Deduction B) from the total cost, the cost range would now be $325,651 to $1,101,321; a difference of $775,670.

The cost range per mgd of hydraulic capacity is $207,504 to $574,620, a spread of $367,116. By applying Deductions A and B, the range becomes $177,278 to $367,107 for a spread of $189,829.

RATIONALE FOR DEDUCTION A

In determining the differences in capital costs associated with constructing sewage treatment plants based on the sample data, it appears that four cost elements, namely, 1) move and mobilize, 2) site dewatering, 3) clearing and grubbing, and 4) landscaping play a significant role. Consequently, these four cost items were combined into what is referred to as Deduction A.

Before the rationale associated with Deduction A can be developed adequately, each item should be generally defined as follows:

1. Move and Mobilize - This item generally refers to costs generated by the contractor during the start-up phase of the construction project. It includes among other things such items as supervision, performance and payment bonds, welfare, insurance, taxes, travel expenses, temporary heat and enclosures, holidays and weather loss pay, and professional fees.

2. Site Dewatering - This item generally refers to the cost associated with reducing the water table elevation to below the level of excavation and maintaining this level until all construction work below this level is completed.

3. Clearing and Grubbing - Clearing involves the removal of trees, shrubs, and bushes found at or above the original ground level. Grubbing involves the complete removal of stumps, roots, boards, logs, and other organic matter found at or below original ground level. Normally, all material collected in the course of clearing and grubbing become the property of the contractor, the cost of disposal (either on or off the construction site) is borne by the contractor.

4. Landscaping - This item generally refers to drainage, roads and walks, grading, seeding, sodding, and planting of shrubs, hedges, or trees.

In view of the above general description directed at the four cost items, it appears that the Contractors or Engineers develop the costs based on less than the required resources, information, and technical assistance to properly evaluate specifications, construction methods, equipment productivity, economics of construction, and comparative material prices. More specifically, each of the above cost items is peculiar to a particular site, but they are not readily comparable on a national basis.

Each of the item bid prices includes the following relevant cost estimates based on location and complexity of the project:

1. Labor Costs - Local, regional or national labor agreements.

2. Material Costs - Consistent with material specifications and suppliers.

3. Equipment Costs - Providing and utilizing the services of equipment.

4. Production Rates - Cost of labor and equipment based on an efficiency rate.

5. Contingencies - Costs attributed to an item consistent with the information available to the estimator.

6. Overhead Cost - Costs attributed to maintaining a construction business as a general contractor over and above costs of labor, material, and equipment. Move and mobilize costs can be considered as an overhead expense. Based on observations, this item is definitely higher for the East Coast firms than for the plants located in other parts of the country.

Each contractor does not necessarily recognize the need for planning and implementing current information on new methods of construction, new equipment and new materials. Traditional attitudes towards the adequacy of old practices are not always examined periodically in order to keep abreast of the continually varying conditions in the industry. Because of this condition, it was extremely difficult to make an accurate cost comparison.

In summary, for the purposes of this study, the rationale associated with the four cost elements referred to as Deduction A were developed by defining each element technically, and then summarizing the various labor, material, and other cost data required to generate an itemized bid price. Furthermore, an attempt was made to qualify the various factors involved in developing the actual cost estimate.

For example, the contractor utilizes information generated by the engineer in the form of plans and specifications, site inspections, estimates of labor, material, equipment, and overhead rates, estimate of productivity, and appropriate contingencies. Each of the estimates reflects in part the size and location of the construction site and the subsurface and surface characteristics of the area. Therefore, costs peculiar to a location or region were excluded to allow comparison between the sample plants based on the following factors:

1. Higher overhead costs such as move and mobilize expenses associated with plants in the northeast based on observations.

2. Clearing and grubbing related to local site conditions.

3. Site dewatering dependent on local water elevation.

4. Landscaping as a function of local preference.

5. Local contractors' viewpoint of each of the four cost elements.

6. Local traditional attitudes.

CONCLUSIONS

1. Based on the data matrix, the Northeast Region plants indicate a larger cost per mgd as compared to the other plants (Figure A-1). According to the data, the Northeast Region plants vary between $489,686/mgd and $1,334,709/mgd, while remaining plants vary between $212,654/mgd and $470,402/mgd.

2. Based on the sample data, it appears that the treatment plants located in the Northeast Region are generally smaller in size (design capacity) than the plants in the control group. Smaller plants tend to have higher costs per mgd. Therefore, in order to develop a rational comparison between these plants, the costs per mgd were corrected by a factor which takes into account the size of the plant.

   A method of estimating the cost of a treatment plant based on its capacity and comparing it to a plant with a known cost and capacity was developed. The relationship is expressed by the equation:

$$C_2 = C_1 \left(\frac{V_1}{V_2}\right)^{0.6}$$

   C = Cost
   V = Capacity
   0.6 = Lang Factor

   By taking Lee, Massachusetts (Plant 7) as the base plant (since it is located in the Northeast and has a convenient capacity of 1 mgd), the graph of Figure A-2 can be developed. The plant cost used in this graphic comparison is the adjusted cost per mgd after applying Deductions A and B.

   From this comparison, it should be noted that there are five plants costing more than Plant 7, which ranked second highest on the basis of absolute dollar cost. It is also important to note that Plants 8 and 9 (Northeast Region) are higher in cost, but Plants 1, 2, and 3 (California), which were low in absolute dollar cost ranking, show a relatively higher ranking in adjusted cost.

3. According to the data matrix, the Northeast treatment plants are closely correlated with the higher cost elements related to the control building by an approximate magnitude of two to four fold. It seems reasonable that plants located in the Northeast Region could be correlated with a higher value system

directed at aesthetics, architectural considerations and quality materials, including heating systems. Therefore, the higher cost associated with control buildings is a reasonable and acceptable cost element.

4. As a cost element, move and mobilize costs associated with the Northeast plants are greater than those of the remaining plants.

5. Two of the treatment plants outside the Northeast Region were designed on the basis of lower than normal per capita sewage flows (Plant 1 - 67 gpcd; Plant 2 - 83 gpcd). If the design engineer based his plant design on the higher per capita sewage flows, it is clear that the cost per mgd is also higher. This fact also contributed to the higher cost per mgd associated with the Northeast Region.

6. Other cost factors such as mechanical piping, mechanical equipment, and electrical items appear to be higher in the Northeast Region, but these factors should be analyzed in depth based on the individual process design and plant layout. It is also important to note that additional factors such as material availability, job efficiency, management, and mechanization should be considered at a later date.

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COMPARISON OF NUMBER OF PLANTS VS. COST PER MGD.

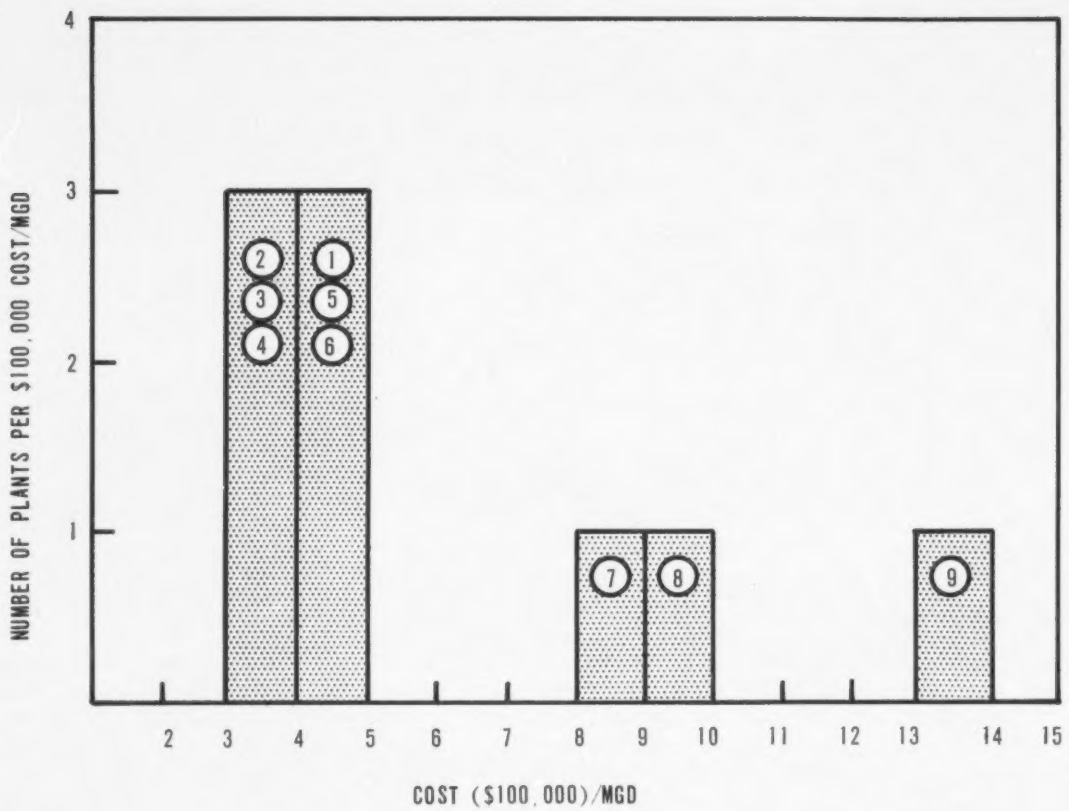

FIGURE A-1

ENVIRONMENTAL PROTECTION AGENCY
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COMPARISON OF TOTAL COST VS. PLANT CAPACITY

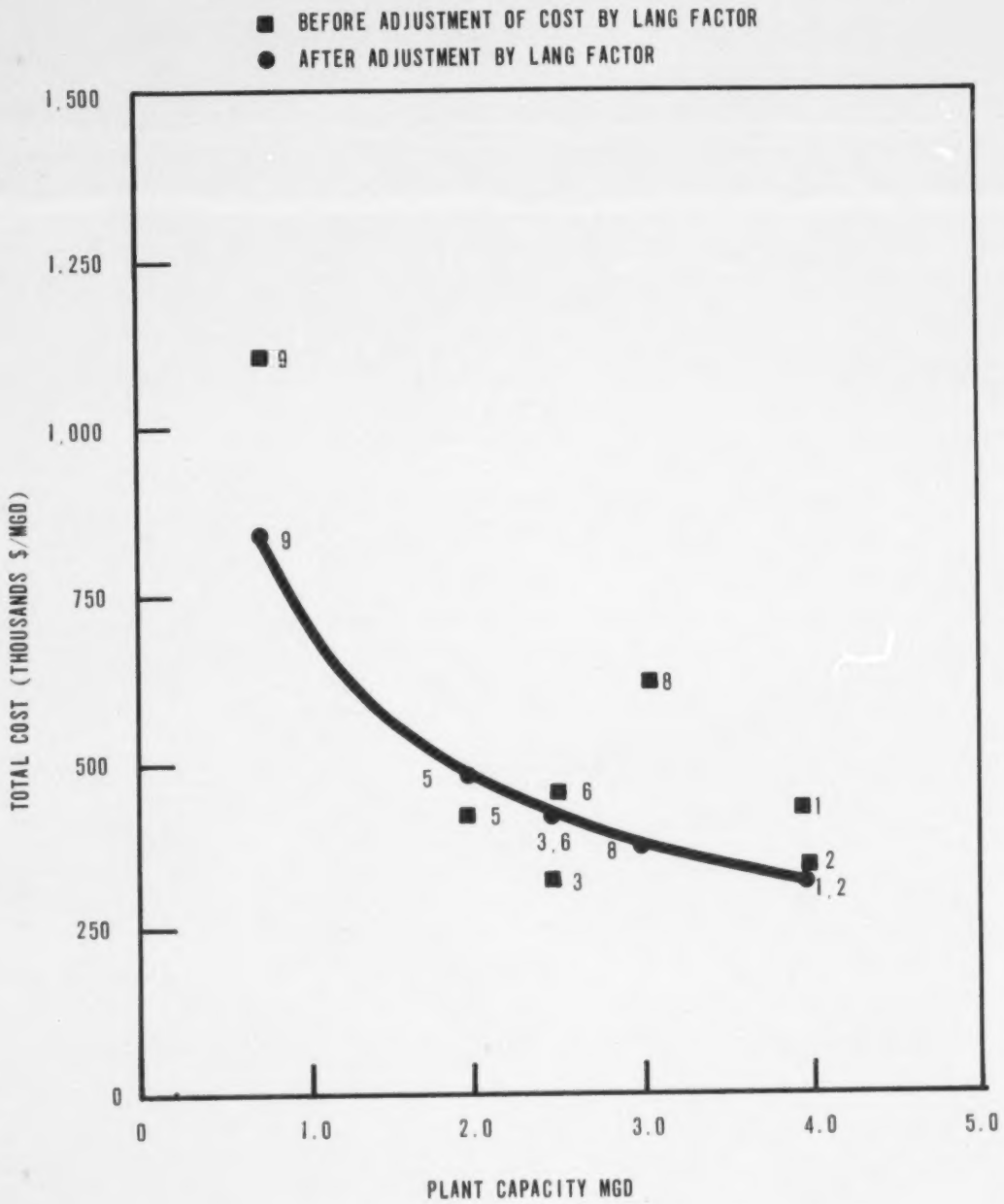

FIGURE A-2